COVER SHEET

Preparatory processes in a case of hemi-parkinsonism

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Summary

Reaction times and movement times were recorded in a subject with parkinsonian symptoms confined largely to the left side of the body. Advance information concerning the movement was varied, being with complete, partial or no preparation. The results suggest that processing of preparation for the movement is not qualitatively different for the more affected side, but is substantially slowed.

Introduction

We describe the results for a single Parkinson's disease subject who participated in a larger study involving seven other parkinsonians and eight neurologically normal controls, reported elsewhere [3]. The subject in question had symptoms confined largely to the left side and therefore provided an opportunity to compare the preparation of movement on the two sides. By providing advance information bout the upcoming movement, it is possible to determine whether the planning of movement is qualitatively different for the two sides through patterns in the response latencies [4]. Yokochi et al. [7], in finding a bilateral slowing of reaction time in parkinsonians with symptoms largely on the left side but a unilateral slowing for those with right-side symptoms, speculated that the cause is an asymmetry of basal ganglia function, in which the right basal ganglia have primary responsibility for an activation mechanism, and that bilateral slowing in left hemi-parkinsonism "would be related to the complex behavior function of the caudate". If complex behavior is differentially impaired, one might expect that in addition to the overall prolongation of reaction time on the side contralateral to the lesion, a parkinsonian with left-side symptoms would show reaction times that are affected by the amount of processing associated with the movement. It is this issue which is addressed by the experiment reported.

Subject and methods

The subject was a 58-year-old woman who had been diagnosed as having Parkinson's disease 7 years prior to the study. Her primary symptoms were moderate to severe bradykinesia, mild tremor and moderate rigidity predominately on the left side, especially the left arm and hand.

The only evidence of right-side involvement was some degree of bradykinesia. The subject was taking levodopa plus carbidopa (Sinemet) at the time of the study.

The apparatus and procedure have been fully described elsewhere [3]. The subject sat at a table on which were mounted ten microswitches in two parallel sagittally oriented rows of five, 3.5 cm apart. The center microswitch in each row was designated the home key. In front of the subject was a display of light-emitting diodes (LEDs) arrayed in the same manner as the keys. LEDs and microswitches were connected to the laboratory LSI-11/03 micro-computer, which was used to control the experiment and for data storage and analysis.

The subject wore a “visor” which occluded vision of her hands and the keys, so that movements were made without visual guidance, but vision of the LEDs was always available. Each trial started with the subject’s index fingers pressing the home keys. A visual warning signal (the illumination of the yellow LEDs corresponding to the home keys) was given, followed by a "precue". The precue was the illumination of one, two, four or all eight of the LEDs corresponding to the target keys. Depending on how many and which LEDs were illuminated, the subject was thus given complete, partial, or no advance information about the direction, extent and arm to be used in the subsequent movement. After 1 s the precue LED (s) were extinguished, and after a further 1 s one of the precue LEDs was re-illuminated, serving as the response signal. The subject was required to move the index finger from the home key to the key indicated by the response signal as rapidly as possible, keeping the index finger of the hand on the side contralateral to the response in place on its home key.

After initial practice, the subject participated in a total of 15 blocks of 64 trials each, for a total of 120 trials in each of eight conditions. The conditions are defined by the three "dimensions" of the movement which were not precued: i.e., those for which the subject had to specify values (short, long; left, right; away from or towards the body) after the response signal, or by uncertainty level (0, 1. 2, or 3 dimensions unknown before the response signal), as follows: none (uncertainty level: 1); arm, direction, extent (uncertainty level: 1); AE, AD, DE (uncertainty level: 2); and ADE (uncertainty level: 3).

Results

The reaction times (RTs) for the eight conditions are depicted in Fig. 1, with responses made by the left and right arms shown separately. A clear effect of experimental conditions showed that the subject could initiate movement more rapidly when partial or complete advance information was available ($F= 79.5$, $df = 7.98$. $P < 0.001$). RTs of the left arm were significantly slower than those of the right by an average of 105 ms ($F = 244.5$, $df = 1,14$, $P < 0.001$).

There was no overall interaction between arm and dimension(s) remaining to be specified ($F = 1.7$, $df = 7,98$, $P > 0.1$). To assess the relative effects of advance information on the RTs of left and right arms, regression equations were calculated separately for each using the mean RTs for each uncertainty level. The intercepts were 412.0 ms (left arm) and 295.8 ms (right arm), and the slopes were almost identical: 83.0 (left arm) and 83.3ms (right arm) for each

increment in uncertainty level. These linear regressions accounted for 99.7% and 98.2% of the variance in uncertainty level means for left and right arms, respectively.

The only condition in which a larger difference between the arms was evident was when only the arm to be used was unknown in advance. In this instance, the difference was 161 ms. When the three uncertainty level one conditions were analyzed separately, a significant interaction between arm and condition emerged ($F=4.24$ $df=2,28$, $P<0.05$). Tukey's Honestly Significant Difference test revealed that for left arm movements, the RT was significantly longer when arm rather than extent remained to be specified ($P<0.05$), with the difference between arm and direction RTs marginally non-significant ($P<0.06$). There were no significant differences in the corresponding comparisons for the right arm RTs. Movement times showed the expected slowness of the left arm ($F= 403.7$, $df = 1,119$, $P < 0.0001$). Since no interactions were found, the MT values shown in Table 1 will not be discussed.

Discussion

As expected, latencies and movements for the more affected side were, on average, slower than for the less affected side. Of more interest is the absence of a different relationship between advance information and reaction time between the two arms. The data suggest that the subject was no less capable of planning movements for the left side than for the right side, when given partial or complete advance information about the forthcoming movement. These data support earlier published findings on Parkinson's disease patients [3-5]. The subject's right basal ganglia were evidently capable of regulating "complex behavior", i.e., the advance planning of a

movement. That the reaction time for the left side is not differentially affected by the uncertainty level suggests that response selection is unimpaired. If response selection were slowed, the RTs for the left side would increase faster than those for the right side as a function of the number of response alternatives which remain after the precue [6]. There remains, however, a residual slowing, which we attribute to a process associated with slower perception of the stimulus or - more probably - with some delay in the output of the response after it has been selected.

The large difference between the arms when arm alone is not precued may be caused by a preferential preparation of the less affected side when the choice is simply one of which arm will be used. This would lead to a relatively short reaction time for the right are, since this would have been prepared, and would also produce a relatively prolonged reaction time if the left arm had to be used since "reprogramming" of the prepared response would be entailed. This effect would not be seen in other conditions in which the arm to be used was unknown prior to the response signal (i.e., AE, AD, and ADE), since the increased number of response alternatives (four or eight) would discourage the preparation of a single, preferred response.

Heterogeneity of symptoms is characteristic of parkinsonism, and generalizing from the reaction time data of a single subject should be done with caution [1]. Nevertheless, the similarity of reaction time-uncertainty level slopes in this within-subject comparison provides support for the view expressed by Rafal et al. [2] that bradykinesia is not necessarily accompanied by a change in the rate of information processing (at least that which is involved

in selecting a discrete aiming movement), but rather, by an additive delay in initiating the movement.

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References

1. Evarts EV, Teravainen H, Calne DB (1981) Reaction time in Parkinson's disease. Brain 104: 167-186

2. Rafal RD, Posner MI, Walker JA, Friedrich FJ (1984) Cognition and the basal ganglia. Brain 107: 1083-1094

3. Stelmach GE, Worringham CJ, Strand EA (1986) Movement preparation in Parkinson's disease: the use of advance information. Brain 109: 1179-1194

4. Stelmach GE, Worringham CJ, Strand EA (1987) The programming and execution of movement sequences in Parkinson's disease. Int J Neurosci 36: 55-68

5. Stelmach GE, Worringham CJ (1988) The control of bimanual aiming in Parkinson's disease. J Neurol Neurosurg Psychiatry 51 :223-231

6. Theios J (1975) The components of response latency in simple human information processing tasks. In: Rabbitt PMA, Dornic SA (eds) Attention and performance V. Academic Press, London, pp 4l8-440

7. Yokochi F, Nakamura R, Narabayashi H (1985) Reaction time of patients with Parkinson’s disease with reference to asymmetry of neurological signs. J Neurol Neurosurg Psychiatry 48: 702-705

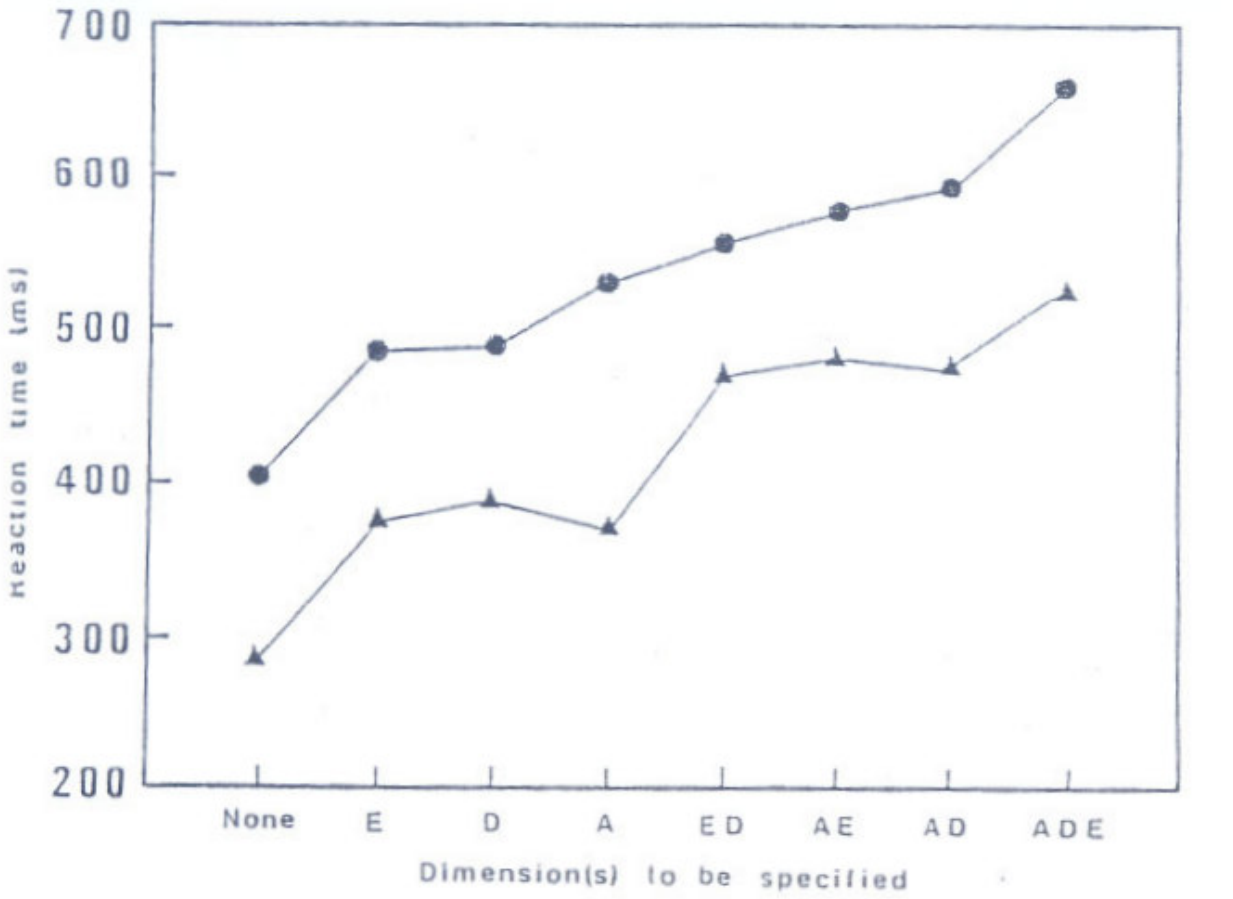

Fig. 1. Mean reaction time as a function of dimensions to be specified and arm used. The abbreviations for movement dimensions refer to extent (E), direction (D), and arm (A). Filled circles (left); filled triangles (right).

Table 1. Mean movement time (ms) as a function of condition and arm used in the movement

	Dimension(s) to be specified:							
	None	E	D	A	ED	AE	AD	ADE
Left Arm	570	533	579	611	572	563	600	572
Right Arm	367	379	362	392	356	356	367	387

A = arm; D = direction; E = extent